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How Accurate Is Dobutamine Stress Electrocardiography for Detection of Coronary Artery Disease?

Comparison With Two-Dimensional Echocardiography and Technetium-99m Methoxyl Isobutyl Isonitrile (Mibi) Perfusion Scintigraphy

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Objectives. **This study was designed to establish the appropriate diagnostic criteria for positive dobutamine electrocardiographic (ECG) stress test results and to compare their accuracy with those of dobutamine two-dimensional echocardiography and perfusion scintigraphy.**

Background. **Conventional criteria for positive findings on ECG exercise testing may not be appropriate for use with dobutamine ECG stress testing.**

Methods. **One hundred twenty-nine consecutive patients with an interpretable ECG and without previous myocardial infarction were prospectively studied at the time of coronary arteriography. All completed a standard dobutamine protocol (5 to 40 μg/kg body weight per min in 3-min dose increments) without side effects. Significant coronary artery disease, defined as >50% lumen diameter stenosis of a major epicardial coronary artery on coronary angiography, was present in 83 patients. Empiric receiver operating curves were generated for various ECG criteria derived from computer-averaged signals.**

Results. **The best ECG criterion, with a sensitivity of 42% and a specificity of 83%, was an ST segment shift, relative to baseline, of 0.5 mm 80 ms after the J point. The sensitivity of this criterion was greater than that of the conventional criterion of 1-mm ST segment depression 60 (23%) or 80 (18%) ms after the J point, was comparable to that of chest pain occurring during the test (44%, p = NS) but remained inferior to the sensitivities of technetium-99m methoxyl isobutyl isonitrile (mibi) perfusion (76%) or stress echocardiography (76%, $p < 0.001$, for both). The specificity of this criterion was not significantly different from that of technetium-99m mibi perfusion tomography (65%) or stress echocardiography (89%) but was superior to that of chest pain (59%, $p < 0.025$).**

Conclusions. **We conclude that this new criterion for dobutamine electrocardiography is specific but that an imaging technique is still required to accurately predict coronary artery disease.**

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Exercise testing is widely used for the noninvasive diagnosis of coronary artery disease in patients with a chest pain syndrome. However, to achieve optimal accuracy, maximal exercise is required (1). In patients unable to exercise maximally, pharmacologic stressors are an increasingly used alternative (2,3), and among these dobutamine is one of the most popular (4,5). Experimental studies have indicated that dobutamine could induce ischemia in the presence of coronary lesions (6,7), and clinical trials have validated its efficacy for the detection of coronary artery disease in combination with either two-dimensional echocardiography (8–12) or scintigraphic perfusion imaging (13,14). In view of the number of patients unable to exercise maximally (2), performance of a dobutamine stress in combination with electrocardiographic (ECG) testing alone would be an attractive alternative. Indeed, some data (15) suggest such combination testing could be a simple and accurate method to predict coronary artery disease in patients with angina. However, although few data are available comparing dobutamine ECG monitoring with dobutamine echocardiography or scintigraphy in unselected patient groups, all such studies (8,12,14,16) have shown a significant benefit for either imaging technique versus the dobutamine ECG. However, these results may be due to the application to the dobutamine test of the ST segment criteria validated for exercise testing. Indeed, different test conditions, including the achievement of a lower work load with dobutamine, could make these criteria inappropriate. Thus, the purpose of this study was to determine the optimal ECG criteria for the

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diagnosis of coronary artery disease in association with dobutamine stress by use of precise computer measurements and to compare their accuracy with those of stress echocardiography and perfusion scintigraphy.

Methods

Patients. Consecutive patients referred for diagnostic coronary angiography were prospectively enrolled in the study over a 1-year period. Patients with a clinical history or ECG evidence of previous Q wave myocardial infarction, unstable angina, malignant arrhythmias, cardiomyopathy, severe valvular disease or severe hypertension (systolic pressure >200 mm Hg, diastolic pressure >120 mm Hg) were excluded. For the purpose of this study, 65 patients whose dobutamine stress test had to be interrupted prematurely because of side effects (i.e., hypotension, arrhythmias, hypertension, dyspnea, vagal reactions or anxiety) and 11 other patients with an uninterpretable ECG (5 with left bundle branch block, 1 with right bundle branch block and 5 with ECG evidence of left ventricular hypertrophy) were also excluded. All other ECGs were considered suitable for analysis. The final group comprised 129 patients (95 men, 34 women; mean [±SD] age 56 ± 9 years, range 31 to 78). Typical angina was present in 99 patients (77%); the other 30 had sufficient symptoms to warrant angiography. The pretest probability of disease, calculated for each patient on the basis of age, gender and symptoms (17), was 53 ± 26%. No patient was taking digitalis.

Coronary angiography. Coronary angiography was performed with the Judkins technique in all patients. Films were reviewed by experienced observers who were unaware of the dobutamine results. Coronary stenosis was quantitated manually with the use of a previously validated method (18). Coronary artery disease was defined as >50% lumen diameter stenosis of a major epicardial coronary segment.

Of the 129 patients, 83 had angiographic evidence of coronary artery disease, including 14 with three-vessel disease, 30 with two-vessel disease and 39 with single-vessel disease; left main coronary artery disease was present in 6. The remaining 46 patients had either normal coronary arteries (n = 39) or <50% stenoses (n = 7).

Dobutamine stress. Stress testing was performed within 2 days of cardiac catheterization after a clinical history was recorded, a rest ECG and echocardiogram were obtained and intravenous access was secured. Dobutamine was infused in 3-min dose increments of 5, 10, 20, 30 and 40 μg/kg body weight per min. The end point was achievement of peak dose (n = 104) or severe anginal pain (n = 25) whether or not accompanied by severe impairment of left ventricular function. Technetium-99m methoxyl isobutyl isonitrile (mibi), 20 mCi, was injected intravenously 1 to 2 min before completion of the stress. If severe ischemia necessitated early termination of the test, dobutamine was continued at a lower dose for 1 min after technetium-99m mibi injection.

Stress ECG. The ECG was monitored continuously using the three orthogonal vectorcardiographic leads, X, Y and Z, computed from the unipolar Frank lead system (19). To allow easy access to the conventional echocardiographic windows, the epigastric ECG electrode was set slightly higher than usual, and the left midaxillary electrode was set 1 to 2 cm lower down compared with the classical leads. The ECG samples were filtered and recorded digitally during the last 20 s of each minute throughout exercise and recovery. The digitized ECG samples were averaged and processed off-line by computer (Modcomp Classic 7835), as described previously (20). The zero reference level was set from 10 to 30 ms before onset of the QRS complex. ST segment changes were calculated by computer at 0, 20, 40, 60 and 80 ms after the J point and reviewed by two experienced observers. In all but five patients, the maximal ST segment shifts were analyzed during the last step of dobutamine infusion. In four of these five patients, the maximal level of ST segment changes occurred 1 min after peak stress, and in one patient, it occurred 3 min after peak stress; in these five patients the maximal ST segment shifts were considered for analysis at those times. Patients showing ST segment elevation were analyzed separately but their data were considered as equivalent ST segment depression for the receiver operating curve analysis.

Perfusion scintigraphy. Stress perfusion imaging was performed 1 to 2 h after the injection of technetium-99m mibi. Rest imaging was usually performed on another day, but in a minority of patients both stress and rest imaging were performed on the same day for scheduling reasons (21). Single-photon emission computed tomographic data were acquired over 180° with use of a large-field single-crystal camera and high resolution collimator (General Electric 400 AC/T). Transaxial images, obtained by back-projection using a Shepp-Logan filter, were reconstructed into short-axis and vertical and horizontal long-axis views. Perfusion scintigrams were interpreted in blinded manner by the consensus of two experienced observers. Stress and rest images were compared qualitatively on a segmental basis.

Stress echocardiography. Two-dimensional echocardiographic images were acquired in parasternal long- and short-axis and apical four- and two-chamber views, recorded on tape and digitized on-line (Prevue, Nova Microsonics) at baseline and at dose infusions of 10, 30 and 40 μg/kg per min. Cine loops were interpreted in blinded manner in quad-screen format by the consensus of two experienced observers, in accordance with previous guidelines (22). A positive test result was defined by the appearance of a new wall motion abnormality or failure of wall motion to improve relative to hyperkinetic response to maximal stress.

Statistical analysis. The sensitivity, specificity, accuracy and positive and negative predictive values of dobutamine stress electrocardiography, echocardiography and technetium-99m mibi scintigraphy were obtained in the usual fashion. The Youden index, which is not influenced by prevalence, was calculated from the formula Youden index = Sensitivity + Specificity − 100.

Empiric receiver operating curves were generated using 0.2, 0.4, 0.5, 0.6, 0.8, 1, 1.2, 1.4, 1.6 and 1.8 mm of absolute ST segment shift at peak stress to define coronary artery disease at

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Table 1. Sensitivity and Specificity of Dobutamine Electrocardiography, Using Different Criteria of ST Segment Shift

	≥ 1.8	≥ 1.6	≥ 1.4	≥ 1.2	≥ 1.0	≥ 0.8	≥ 0.6	≥ 0.5	≥ 0.4	≥ 0.2
ST J										
Sens	11	12	19	24	40	60	71	81	88	95
Spec	98	98	98	89	74	65	35	26	13	2
ST 20										
Sens	11	12	13	19	35	51	67	76	80	94
Spec	100	100	96	96	83	63	41	33	24	7
ST 40										
Sens	5	11	12	17	25	36	58	66	73	86
Spec	100	100	100	96	93	74	57	48	33	24
ST 60										
Sens	2	8	11	14	23	28	44	49	59	77
Spec	100	100	100	100	98	87	72	65	50	35
ST 80										
Sens	4	6	8	12	18	25	36	37	45	63
Spec	100	100	100	100	93	91	87	85	72	52
dST J										
Sens	5	8	14	19	31	53	69	75	82	92
Spec	100	98	98	96	80	61	39	28	17	4
dST 20										
Sens	4	8	12	16	30	42	64	73	79	93
Spec	100	100	100	98	87	74	48	35	30	11
dST 40										
Sens	4	6	10	13	20	35	51	59	69	83
Spec	100	100	100	100	96	89	67	52	43	20
dST 60										
Sens	1	6	7	13	18	27	42	52	58	81
Spec	100	100	100	100	100	98	80	67	59	39
dST 80										
Sens	2	5	7	12	16	22	36	**42***	48	60
Spec	100	100	100	100	100	96	87	**83***	72	52

*Best criterion. dST = relative to baseline ST segment shift (mm); J = J point; ST = absolute value of ST segment shift (mm); 20, 40, 60, 80 ms = after the J point.

0, 20, 40, 60 and 80 ms after the J point. For each patient, the relative ST segment shift was also calculated by subtracting the baseline ST segment values from the absolute ST segment shift at peak stress, and additional curves were generated at each stage for ST segment shift relative to baseline. To preserve with dobutamine electrocardiography a specificity comparable to that of exercise as first-step reference standard noninvasive test for detection of coronary artery disease (1,20), a specificity >80% was stipulated, and the best criterion was defined by the point visually closest to the top left corner of the receiver operating curve, which also corresponded to the highest Youden index value.

Because dobutamine is thought to provoke its effects by increasing external cardiac work (6,7,23) and because submaximal tests, defined by inability of the patient to achieve maximal predicted heart rate, have been reported to be a potential cause of poor sensitivity in exercise testing (1,20), a subgroup analysis was performed for maximal and submaximal tests. For each patient, the maximal age-predicted heart rate for exercise was calculated using the Astrand formula: Maximal predicted heart rate = 220 beats/min − Age. A cutoff point of 70% of the maximal predicted heart rate was used to separate maximal from submaximal tests.

The results for each test were compared by using the McNemar test. Differences between subgroups were compared with a chi-square (with or without the Yates correction) or Fisher exact test, depending on the minimal expected value. Continuous variables were compared with the Student t test for unpaired data. A p value of 0.05 was considered statistically significant.

Results

Conventional ECG criteria. Prediction of coronary artery disease based on the conventional ECG criteria of 1-mm ST segment shift 60 ms after the J point gave a sensitivity of 23% in the 83 patients with >50% coronary stenoses and a specificity of 98% in the 46 patients with no or minor coronary lesions. The overall accuracy was 50%, and the Youden index was 21. The use of 1-mm ST shift 80 ms after the J point gave a sensitivity of 18%, a specificity of 93%, an overall accuracy of 45% and a Youden index of 11. Significant ST segment elevation (≥1 mm 80 ms after the J point) was present only in five patients—four with significant coronary stenosis and one with normal coronary arteries.

Receiver operating curves. Values for sensitivity and specificity were calculated for various criteria of ST segment shift at different time intervals after the J point (Table 1). All receiver operating curves were very close to the identity line (Fig. 1),

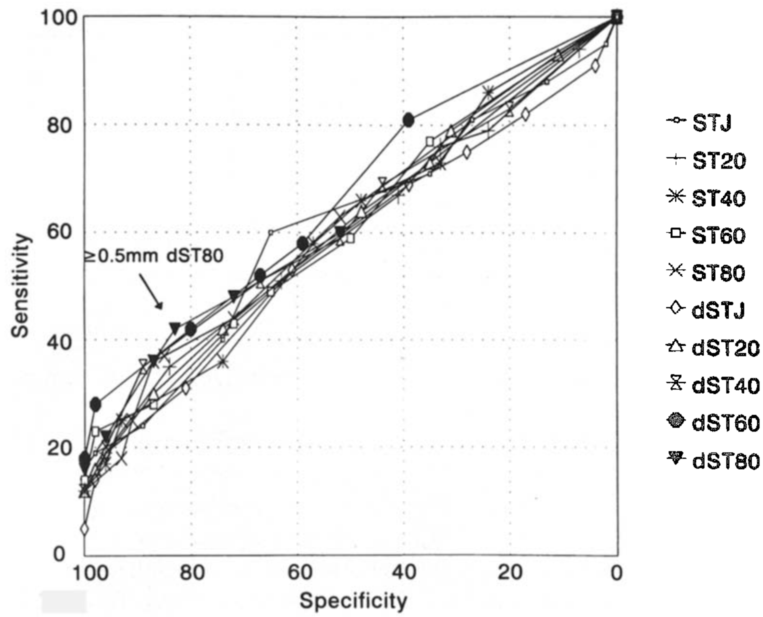

Figure 1. Receiver operating curves with different electrocardiographic (ECG) criteria to define coronary artery disease. Absolute ST segment shift (ST) was analyzed at 0 (J), 20, 40, 60 and 80 ms after the J point. Additional curves were created for ST segment shift relative to baseline (dST) at the same time intervals. The arrow indicates our best ECG criterion, with a specificity >80%, corresponding to an ST segment shift relative to baseline of 0.5 mm 80 ms after the J point.

and the best point with a specificity >80% corresponded to an ST segment shift relative to baseline of 0.5 mm 80 ms after the J point. The sensitivity of this new criterion was 42%, specificity 83%, positive predictive value 81%, negative predictive value 56% and overall diagnostic accuracy 57%; the Youden index was 25. A similar value of Youden index was also obtained for an ST segment shift relative to baseline of 0.8 mm 60 ms after the J point, with a sensitivity of 27%, a specificity of 98% and an overall accuracy of 53%. Exclusion of the seven patients with <50% stenoses did not alter these results significantly.

Analysis of subgroups. The accuracy of the best ECG criterion, as defined earlier (0.5 mm of relative ST segment shift 80 ms after the J point), was examined in different subgroups of patients.

Gender and age. Sensitivity, specificity or accuracy did not differ significantly between men and women (Table 2). However, the prevalence of coronary artery disease was different between the two subgroups (75% for the 95 men and 35% for the 34 women, $p < 0.001$). Similarly, despite a reduction in sensitivity in patients <50 years old, no significant difference in the accuracy of dobutamine ECG results was apparent on the basis of age.

Beta-adrenergic blockade. Because beta-adrenergic blockade might decrease the sensitivity of a dobutamine stress test by decreasing maximal achieved heart rate (24), subgroups of patients receiving or not receiving antianginal therapy were analyzed (Table 2). There was a decrease in specificity in patients receiving beta-blocker therapy, but accuracy remained

Table 2. Comparison of Patient Subgroups

	Patients (no.)	Prev (%)	TP (no.)	Sens (%)	FP (no.)	Spec (%)	Acc (no.)
Gender							
Men	95	75	30	42	5	79	52
Women	34	35*	5	42	3	86	71
Age							
≤ 50 years	34	59	4	20†	1	93	50
51 to 59 years	47	66	14	45	3	81	57
≥ 60 years	48	67	17	53	4	75	62
Medication							
BBl	31	71	10	43	4	50‡	45
NC	23	78	8	44	1	80	52
BBl or NC	54	74	18	44	5	62	48
None	75	56	17	40	3	91	63
Total	129	64	35	42	8	83	57

*$p < 0.001$ versus men. †$p < 0.02$ versus ≥60 years. ‡$p < 0.02$ versus patients without antianginal therapy (None). Acc = overall accuracy; BBl = patients taking beta-adrenergic blocking agents; FP = false positive test findings; NC = patients taking nitrates or calcium channel blocking agents; Prev = prevalence of coronary artery disease; Sens = sensitivity; Spec = specificity; TP = true positive test findings.

Table 3. Comparison of Maximal and Submaximal Tests

%MHR	Patients (no.)	Prev (%)	HR (beats/min)	RPP (10^3 beats/min mm Hg)	TP (no.)	Sens (%)	FP (no.)	Spec (no.)	Acc (%)
Submaximal text (< 70%)	73	64	90 ± 17*	15.5 ± 3.4*	17	36	8	69†	48‡
Maximal test (≥ 70%)	56	64	129 ± 11	23 ± 3.1	18	50	0	100	68
Total	129	64	107 ± 24	18.8 ± 4.9	35	42	8	83	57

*$p < 0.001$, †$p < 0.02$, ‡$p < 0.05$ versus maximal test. Unless otherwise indicated, values are expressed as mean value ± SD. HR = maximal achieved heart rate; %MHR = percent achieved of maximal age-predicted heart rate; RPP = maximal achieved rate-pressure product; other abbreviations as in Table 2.

nonsignificantly different between subgroups receiving beta-blockers (n = 31), nitrates or calcium channel blockers (n = 23) or no active antianginal therapy for ≥24 h (n = 75).

Submaximal tests. Subgroups of patients achieving or failing to achieve 70% of maximal age-predicted heart rate were considered to have performed a maximal or submaximal test, respectively. These two subgroups comprised, respectively, 56 and 73 patients (Table 3). There was a significant decrease in accuracy mainly due to a lower specificity in submaximal tests, similar to that observed with patients receiving beta-blockers.

Angina at peak stress. Chest pain occurred at peak dose in 55 (43%) of all patients. Chest pain occurred in 36 patients with coronary artery disease (sensitivity 44%, p = NS vs. electrocardiography), and in 19 without coronary disease (specificity 59%, $p < 0.025$ vs. electrocardiography). The overall accuracy of chest pain as a predictor of coronary artery disease was 49% (p = NS vs. electrocardiography), and the Youden index was 3.

Angina occurred in association with our best ST segment shift criterion in 17 patients with coronary artery disease (sensitivity 20%) and in 1 patient without coronary lesions (specificity 98%). The diagnostic accuracy of this association was 48%, and the Youden index was 18. Use of either angina or ST depression, or both, to denote the presence of coronary disease gave a sensitivity of 65% but a specificity of only 43%. The diagnostic accuracy of this combination was 57%, and the Youden index was 8.

Stress echocardiography and perfusion scintigraphy. Of the 83 patients with coronary artery disease, 63 were correctly identified by two-dimensional echocardiography (sensitivity 76%, $p < 0.001$ vs. electrocardiography) and 63 by technetium-99m mibi scintigraphy (sensitivity 76%, $p < 0.001$ vs. electrocardiography and p = NS vs. echocardiography). This greater sensitivity of imaging was similarly apparent in subgroups of patients with single-vessel or multivessel disease (Fig. 2). In 23 of the 35 patients correctly identified by the new ECG criterion, results of both two-dimensional echocardiography and perfusion scintigraphy were also positive, and ECG results were only positive in three patients with negative findings on echocardiograms and scintigrams (Table 4). Only four patients with coronary artery disease were considered to have negative findings by all three tests.

Of the 46 patients without significant coronary artery disease, 5 had new wall motion abnormalities (specificity 89%, p = NS vs. electrocardiography) and 16 had technetium-99m mibi perfusion defects (specificity 65%, p = NS vs. electrocardiography and <0.05 vs. echocardiography). The overall accuracy was 81% for echocardiography ($p < 0.001$ vs. electrocardiography) and 72% for scintigraphy ($p < 0.01$ vs. electrocardiography and p = NS vs. echocardiography). None

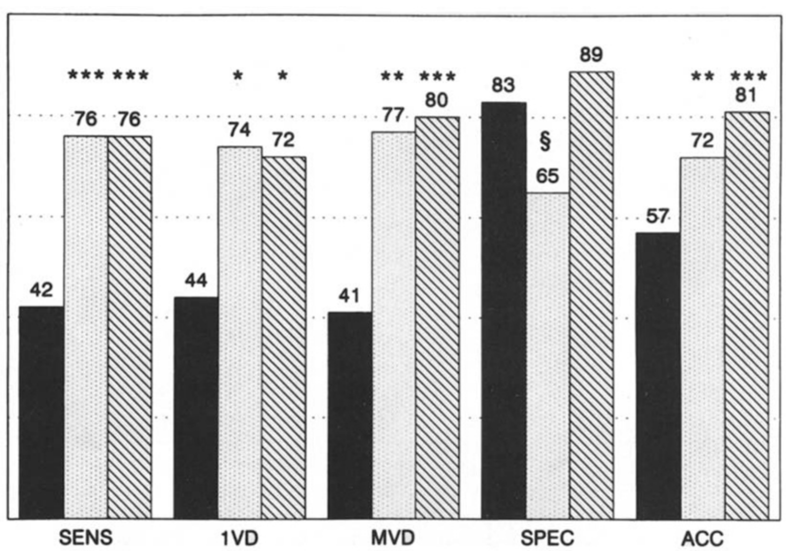

Figure 2. Comparison between electrocardiography (**solid bars**) (ST segment shift relative to baseline of 0.5 mm 80 ms after the J point), technetium-99m mibi scintigraphy (**dotted bars**) and stress two-dimensional echocardiography (**hatched bars**) in single-vessel (1VD) and multivessel (MVD) disease. Sensitivity (SENS), specificity (SPEC) and accuracy (ACC) are expressed as percent. *$p < 0.025$, **$p < 0.01$, ***$p < 0.001$ versus electrocardiography. §$p < 0.05$ versus two-dimensional echocardiography.

Table 4. Concordance Between Different Tests

ECG	2D Echo	Tc-99m Mibi	CAD	No CAD
P	P	P	23	0
		N	6	0
	N	P	3	5
		N	3	3
N	P	P	27	1
		N	7	4
	N	P	10	10
		N	4	23

CAD = coronary artery disease; ECG = electrocardiography; N = negative test result; P = positive test result; Tc-99m Mibi = technetium-99m methoxyl isobutyl isonitrile; 2D Echo = two-dimensional echocardiography.

of these patients had positive findings on all three tests (Table 4). Of the eight patients with false positive ECG findings, five also had a false positive scintigraphic response, whereas the three others were correctly identified by both echocardiography and perfusion scintigraphy.

Use of either electrocardiography or echocardiography, or both, for the diagnosis of coronary artery disease increased sensitivity to 83%, whereas specificity decreased to 72%. The overall accuracy of this combination was 79% (p = NS vs. echocardiography alone). Use of either electrocardiography or scintigraphy, or both, to denote the presence of coronary artery disease gave a sensitivity of 87%, a specificity of 59% and an overall accuracy of 77% (p = NS vs. mibi alone).

Discussion

The results of this study show that the best ECG criterion, determined by use of empiric receiver operating curves, was an ST segment shift, relative to baseline, of 0.5 mm 80 ms after the J point. This criterion allowed detection of coronary artery disease in 35 of 83 patients with coronary stenoses >50% on angiography. It was also positive in 8 of 46 patients without significant coronary lesions. Isolated ST segment elevation, even if strongly suggestive of coronary disease (25), was found in only five patients. Chest pain occurring at peak dose showed a sensitivity similar to that of the ECG, but specificity was significantly lower. This finding is concordant with the reported significance of chest pain occurring during exercise testing (26). The association of chest pain and the ECG showed no significant benefit in accuracy compared with the best ECG criterion. Analysis of different subgroups demonstrated that this poor sensitivity of the dobutamine ECG was not due to a selection bias because the results were confirmed irrespective of gender and age. The accuracy of the dobutamine ECG was even lower in patients failing to achieve 70% of the maximal age-predicted heart rate. This finding is also concordant with the reported low accuracy of both submaximal exercise electrocardiography (1,20) and submaximal dobutamine stress echocardiography (5,24).

Previous results. The dobutamine stress test was first proposed by Berthe et al. (27) to identify multivessel coronary artery disease after acute myocardial infarction. Defining ischemia by the criterion of 1-mm ST depression 80 ms after the J point, these investigators reported that the test had a 77% sensitivity and a 65% specificity in 37 patients, results that improved on those of predischarge submaximal exercise testing. Coma-Canella (28,29), using either angina or 1-mm ST depression as the criterion for positivity, found that dobutamine stress echocardiography had 84% sensitivity and 64% specificity to predict multivessel disease and showed that positive results on a test performed before discharge after acute myocardial infarction were associated with significantly more angina, heart failure, nonfatal reinfarction and cardiac death during a 7.5-month follow-up period.

The detection of coronary artery disease can be more problematic in patients presenting with a chest pain syndrome than in those who are first seen after a myocardial infarction. Coma-Canella (15) suggested that the dobutamine ECG could be a simple and useful test to induce myocardial ischemia in patients with angina. Using anginal pain or 1-mm ST segment shift 80 ms after the J point, or both, the dobutamine ECG showed a sensitivity of 95%, a specificity of 78% and a diagnostic efficiency of 89% to predict coronary artery disease. However, the study patients were not representative of those presenting for the diagnosis of coronary artery disease, and only 20 of the 90 patients had typical or atypical stable angina, the remaining 70 patients having either unstable or prolonged angina. In this group, because the clinical pretest probability of disease would have been high, the dobutamine stress test might not have contributed materially to the diagnosis. To avoid such a selection bias in the present study, we included only ambulatory patients with a chest pain syndrome who were referred for diagnostic coronary angiography, and we excluded patients with previous myocardial infarction or unstable angina. Thus, in our study group, the pretest probability of disease was only 53 ± 26%. We also excluded patients with uninterpretable ECGs or patients whose dobutamine stress tests had to be interrupted prematurely because of side effects, to avoid false negative responses due to inadequate stress. Even in this optimal study group, and despite the use of the new ECG criterion, sensitivity and accuracy were low and only specificity was comparable with previous results.

In contrast, both two-dimensional echocardiography and technetium-99m mibi had a significantly higher sensitivity and accuracy, compared with the optimal ECG criterion, in both single-vessel and multivessel disease. The correct identification of 76% of the patients with angiographic coronary artery disease by echocardiography and by perfusion scintigraphy ($p < 0.001$ vs. electrocardiography for both) confirms the physiologic significance of coronary artery disease in this group and the low sensitivity of a dobutamine stress test performed with ECG monitoring alone. However, in previous studies of dobutamine stress echocardiography and perfusion scintigraphy (8,9,11,13,14), the reported sensitivity and specificity were slightly higher than in the present study. This difference may also be related to differences in patient selection (30) because several of the studies included patients with previous myocardial infarction referred for assessment of the functional significance of their disease or even patients with previous coronary artery bypass grafting. The percent of patients with myocardial infarction or rest wall motion abnormalities ranged from 26% (8) to 44% (11) in these studies.

Only a few studies have directly compared the dobutamine ECG with an imaging technique. Cohen et al. (8) reported in 51 patients with coronary artery disease <10% sensitivity for the dobutamine ECG (>1 mm ST segment shift 80 ms after the J point), in contrast to 86% for dobutamine echocardiography, whereas Mazeika et al. (12), using the same ECG criteria but with an 8-min/step dobutamine protocol found a sensitivity of 47% (vs. 78% with dobutamine echocardiography) in 36 patients with coronary artery disease. In both cases, the values were higher for multivessel than for single-vessel disease. In the present study, we also found slightly higher sensitivities for multivessel than for single vessel disease for echocardiography and perfusion scintigraphy but not for electrocardiography (p = NS).

Finally, the best computerized ECG criterion validated for exercise and currently used in our laboratory is an absolute 1-mm ST segment shift 60 ms after the J point (19,31). The difference from the new criterion developed for dobutamine (less ST segment shift required for a positive diagnosis of coronary artery disease) may reflect the lower work load achieved with this agent than with exercise. The absence of body motion artifacts and the supine position during pharmacologic tests may also be a partial explanation.

Study limitations. This study was designed for a selected group of patients with an interpretable ECG who completed a standard dobutamine protocol without side effects. This design could be considered to include a selection bias, as ~25% of the patients in the initial study group did not achieve the maximal dobutamine dose because the test was prematurely interrupted in response to side effects (5). The exclusion of the latter patients by design was mainly intended to reduce the number of nondiagnostic tests and, hence, to preserve a reasonable chance of having positive ECG findings in patients with coronary artery disease. Despite this selection and the use of an improved ST segment criterion for identifying myocardial ischemia, the dobutamine ECG test lacked sensitivity for detecting coronary disease in our patients. It is likely that the sensitivity of the test would be even less in unselected patients.

Another potential limitation of the study could be the use of the Frank lead system instead of a 12-lead ECG, because the sensitivity of the ECG detecting myocardial ischemia was shown to be dependent on both the presence and the number of precordial leads employed. However, we (20) and others (31,32) have previously shown that all the information required to identify myocardial ischemia with the exercise ECG is contained in X, Y, Z lead data and that the accuracy of the 1-mm ST segment depression criterion is similar with the Frank lead system and the conventional ECG. In addition, digital acquisition and signal averaging offer the advantage of reducing noise and facilitating data processing, allowing for more precise, accurate and reproducible measurements of myocardial ischemia. The ECG leads used in the present study were also slightly different from the classical X, Y and Z leads to facilitate access to the echocardiographic acoustic windows. This difference may also have influenced the results, but the effect would probably not have been more than that of the conventional 12-lead system in which some precordial electrodes also have to be set one intercostal space lower down to accommodate echocardiographic studies.

Conclusions. We reported that the best dobutamine stress ECG criterion for the detection of coronary artery disease with the dobutamine stress test was an ST segment shift, relative to baseline, of 0.5 mm 80 ms after the J point. This criterion alone, even if positive in only 35 of 83 patients with coronary disease, is more specific than the criterion of chest pain occurring during dobutamine infusion and is as specific as stress echocardiography or technetium-99m mibi. Even in our selected group of patients, stress echocardiography and technetium-99m mibi perfusion scintigraphy both had higher sensitivity and diagnostic accuracy than those of any ECG criteria. Addition of the ECG to either of these tests did not improve diagnostic accuracy significantly. Whereas ECG monitoring must always be performed during dobutamine stress testing for safety reasons, such monitoring also has to be combined with an imaging technique to accurately detect coronary artery disease.

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